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Annex I and non-Annex I countries' productive performance revisited using a generalized directional distance function under a metafrontier framework: Is there any convergence-divergence pattern for technology gaps?

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Abstract

Countries rapid economic growth, energy consumption and anthropogenic emissions (GHGs) in the atmosphere are creating serious environmental problem on both global and local scales -. This is while compiled evidence about the relationship between climate change/global warming and the amount of GHG released is present (IEA, 2010). In advance, it is generally accepted that countries production processes, should seriously, take into account environmental sustainability principles and targets. In recent years, there have been a series of studies using a directional distance function dealing with environmental efficiency with the aim of measuring the ability of decision making units (i.e regions, firms, industries, countries) to produce more with less impact on the environment. A scarcity of empirical studies appears concerning the estimation of directional distance function under a metafrontier framework. In this paper we employ a balanced panel of 103 countries from 1995-2011 to shed light on the idiosyncratic performance of countries participating in two distinct different groups (Annex I and non-Annex I) using a generalized directional distance function independent of the direction vector length -. The non-parametric metafrontier framework - used in this study, as a first stage of analysis, is exploited to account for the heterogeneity between countries participating in our sample. In the second stage, a convergence-divergence hypothesis has been examined for the technology gaps estimated for each period. Our findings reveal significant patterns between countries' individual performance.

Key words: Metafrontier; Generalized Distance Function; Technology gaps; Annex-I countries

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1. Introduction

The Intergovernmental Panel on Climate Change (2007) has assessed that over the last 50 years, global warming has been caused due to anthropogenic greenhouse gas emissions (GHGs). The impact of GHGs on climate change has been the top agenda and considered the leading issue for many governments, organizations, economists, researchers and scholars since it threatens countries' sustainable development (Tol, 2009; Weitzman, 2009). The significance of this problem is apparent from cases such as the signing of the Kyoto Agreement in 1997 and subsequent efforts in Copenhagen and Cancun (2010), Durban and Doha (2011), Warsaw (2013) and latest in Paris (2015) to reach an international agreement aimed at reducing greenhouse gas emissions. In the face of climate change repercussions, many countries have devoted a large portion of their resources towards designing and implementing mitigation to achieve a satisfactory level of sustainable development while others (headed by U.S) criticizes insisting on a more voluntary orientation. Furthermore, it is true that Kyoto climate policies put more attention and emphasis on the reduction of global emissions to mitigate climate change (Yu-Ying et al., 2013).

The Kyoto protocol was negotiated in 1997 during the Third Conference of the Parties to the United Nations framework Convention of Climate Change. During its establishment put into discussion the reduction levels of GHGs, most notably CO₂ from fossil fuel combustion, for Annex I and non-Annex I countries in an international agreement framework (Den Elzen and Höhne, 2008). Moreover, in a world where economies are linked by international trade and capital flows emissions abatement of Annex I economies may have, possibly, effect on trade, carbon leakage, transfer and diffusion of energy efficient technologies on non-Annex I economies

(Den Elzen and De Moor, 2002). A further caveat, from the stance of economic theory, considers large economic adjustment costs to Annex I countries (Böhringer, C., Vogt, C. 2003) or consider possible policies (i.e. preferential tariff reductions) for their compensation (Babiker et al. 2000). Furthermore, some studies report the fact that recent Kyoto modifications, including U.S. decision, boil down climate policies as business as usual questioning its economic and environmental impacts for the countries participated in this commitment (Böhringer and Vogt, 2003; 2004).

The level of ambitions for reducing emissions by developed (Annex I) and developing (non-Annex I) countries under the Kyoto agreement was one of the most important aspects in current climate negotiations. Although there have been many attempts for the non-Annex I group to ratify the agreement, several political, institutional and economic barriers appeared to hinder them (Calbick and Gunton, 2014)¹. Thus, the clear distinction for countries participating as Annex I and non-Annex I gathers significant opportunity for engineers, economists, scholars and politicians to examine the negative impact of human activity, in terms of pollution equivalents, even at a country level through this perspective. This growing interest in incorporating undesirable outputs in the production function under the different technological regimes yields, on the one hand, numerous published articles (see Zhang and Choi, 2014) while, on the other hand, introduces several methods for asymmetrically handling the two types of outputs (i.e. Tone, 2001; Cheng and Zervopoulos, 2014).

A common characteristic of these studies is that operates under the assumption of technological isolation (Tsekouras et al., 2016) examining a rather homogeneous

¹ In article 2 of the Agreement technology transfer, financial support for the establishment of environmental friendly technologies and funding of technology express the important elements for the implementation of the agreement.

group (Feroz et al., 2009; Halkos and Tzeremes, 2014). It may also adopt a metafrontier production function in a “mechanistic” way creating groups according to specific criteria ignoring their technological status (Kounetas, 2015). The introduction of the metafrontier production function (Battese et al., 2004) allows technological heterogeneity to be incorporated in productive efficiency analysis and therefore relaxing restrictive technological isolation conditions. In the framework of technological heterogeneity, any positive influence of technological spillovers from domestic mitigation strategies onto productive performance may be eliminated, if the production units are locked-in, or if they exhibit path-dependence of the evolution of their productive performance (Tsekouras et al., 2016).

In this paper we extent a generalized efficiency measure of a directional distance function (Cheng and Zervopoulos, 2014) in a methodological framework which allows the co-examination of (i) efficiency differences in terms of productive performance for countries operating under two distinct technological regimes, (ii) any inter-linkages and flows between the two heterogeneous technologies and more specifically spillover effects on non-Annex I countries (iii) the convergence hypothesis for technology gaps for the examined set of countries. This analytical framework is applied to 103 countries over the 1995-2011 period revealing interesting patterns of productive performance which have not been traced by previous seminal papers on environmental efficiency.

This study unfolds as follows. Section 2 reviews the literature on directional distance functions in conjunction with the metafrontier analysis. Section 3 presents the methodology. Section 4 discusses the selection of input and output variables. Section 5 presents the outcomes of the empirical analysis. Section 6 concludes.

2. Review of the literature

In efficiency and productivity analysis, directional distance functions (hereafter DDF) have also become popular since most production processes generate undesirable output(s) as byproduct(s) (i.e. CO₂ emissions for firms or mortality rate for health systems). The main reason for this increased popularity is the ability of DDF to expand good outputs while reducing bad since the production process of every entity has not only an economic but also an environmental and social output (Färe and Grosskopf, 2000; Färe et al., 2005; Zhang et al., 2013). In this context, many empirical studies have used DDF to investigate the performance of individual DMUs. Extant studies apply DDF to measure energy efficiency (Zhang et al., 2013; Zhou et al., 2012), environmental efficiency (Kounetas, 2015; Kumar and Khanna, 2009; Caramero et al., 2008), sustainability performance (Zhang et al., 2013) and eco-efficiency (Oggioni et al., 2011; Picazo-Tadeo et al., 2012; Zhang et al., 2008; Färe et al. 2007; Kuosmanen and Kortelainen, 2005)².

Focusing now on the methodological approaches that have been used to estimate the abovementioned indexes, the literature classifies three groups according to their framework. The first group contains transformations of conventional DEA models including hyperbolic distance functions (Färe et al., 1989) radial measures (Chambers et al., 1996) and non-radial measures. The second one concerns modifications on the slack-based measures (Tone, 2001) while the third group contains several modifications on the directional distance function (Chung et al., 1997).

Many studies have been recorded incorporating DDFs in order to mostly measure energy and environmental performance of different DMUs. As mentioned

² Zhang and Choi (2014) present a comprehensive review of the literature on DDF related to environmental and energy studies.

above, radial nature of DDF stimulates researchers to develop non-radial measures. For instance, Färe and Grosskopf (2010) and Zhou et al. (2012) extended it in a non-radial model and Mahlberg and Sahoo (2011) proposed a non-radial Luenberger indicator. Extending the DDF, Zhang et al. (2013), Choi et al. (2012) and Zhou et al. (2006) developed several slack-based measures for environmental performance while Fukuyama and Weber (2009) proposed a slacks-based efficiency measure of efficiency combining the ideas of DDF and SBM. In addition, Zaim and Taskin (2000) and Cuesta et al. (2009) developed a hyperbolic efficiency measure while Fukuyama et al. (2011) and Barros et al. (2012) with DDFs proposed slacks-based measures and weighted Russell DDF. Sueyoshi et al. (2010) presented a Range-Adjusted measure model for US coal-fired power plants. Finally, Chang and Hu (2010), Färe and Grosskopf (2010) and Cheng and Zervopoulos (2014) put forth a generalized non-radial DDF while Zhang et al. (2014) presented a sequential generalized directional distance function.

On the other hand, very few studies have taken the potential technology heterogeneity into consideration. First, Oh (2010) using a Malmquist-Luenberg productivity index incorporated group heterogeneity while Kounetas (2015), Chiu et al. (2012) and Yu-Ying Lin et al. (2013) measured, not only technology gaps, but also environmental efficiency technology gaps exploiting the scarcity of similar studies under the presence of heterogeneity.

3. Methodology

Our methodological framework is developed in two interconnected stages. In the first stage, we present the theoretical and methodological underpinnings regarding the estimation of the generalized directional distance function and we discuss the expansion in a metafrontier framework presenting the theoretical base for its

inclusion. In the second stage, we present the theory concerning the convergence hypothesis using a stochastic kernel approach.

3.1 Definitions, notation and technological gaps

The inputs $x = (x_1, \dots, x_m) \in \mathbb{R}_+^m$ are used to produce desirable outputs $y = (y_1, \dots, y_s) \in \mathbb{R}_+^s$ and undesirable outputs $b = (b_1, \dots, b_p) \in \mathbb{R}_+^p$ (i.e. CO2 emissions). In this context, the technology is described as follows:

$$T(x) = \{(y, b) : x \text{ can produce } (y, b)\} \quad (1)$$

where $T \subset \mathbb{R}_+^m \times \mathbb{R}_+^s \times \mathbb{R}_+^p$, which represents the input - desirable output - undesirable output bundles that are technologically achievable.

The desirable outputs (y) are jointly produced with the undesirable outputs (b), modelled as follows:

$$\text{if } (y, b) \in T(x) \text{ and } b = 0 \text{ then } y = 0 \quad (2)$$

The assumptions that the technology satisfies are: (a) closedness, (b) free disposability of inputs and desirable outputs:

$\forall (x, y) \in T$, if $x' \geq x$ and $y' \leq y$ then $(x', y') \in T$, (c) weak disposability of undesirable outputs: $\forall (x, b) \in T \Rightarrow (x, \mu b) \in T \quad \forall \mu \geq 1$, (d) no free lunch: if $(x, y, b) \in T$ and $x = 0$ then $y = 0$ and $b = 0$, (e) doing nothing is feasible: $(0, 0, 0) \in T$, and (f) convexity (Färe et al., 1994).

The technology is described by the following directional distance function (DDF):

$$\bar{D}_T(x, y, b; g_x, g_y, g_b) = \sup\{\beta : (x - \beta g_x, y + \beta g_y, b + \beta g_b) \in T(x, y, b)\} \quad (3)$$

where β denotes inefficiency and the non-zero $g = (g_x, g_y, g_b)$ expresses the direction vector of the inputs, desirable outputs, and undesirable outputs, respectively. The expression (3) reflects simultaneous reduction in inputs, expansion of desirable outputs and contraction of undesirable outputs. Drawing on expression (3), the efficiency is defined as follows: $\frac{1 - \beta}{1 + \beta}$.

In this study, a generalized directional distance function (GDDF) is applied to measure environmental efficiency put forth by Cheng and Zervopoulos (2014). According to this generalized DDF, which is also based on expression (3) and satisfies the assumptions of the technology set, the efficiency is measured by the ratio:

$$\frac{1 - \frac{1}{m} \sum_{i=1}^m \beta g_i / x_{io}}{1 + \frac{1}{s+p} \left(\sum_{r=1}^s \beta g_r / y_{ro} + \sum_{t=1}^p \beta g_t / b_{to} \right)} \quad \text{where } \beta g_i / x_{io} \text{ expresses the proportion of}$$

the reduction in inputs, and $\beta g_r / y_{ro}$ and $\beta g_t / b_{to}$ indicate the proportion of the expansion and contraction of desirable and undesirable outputs, respectively. The efficiency measures obtained from this generalized DDF are units invariant, monotone, translation invariant provided that the Variable Returns to Scale (VRS) technology applies, and reference set invariant (Tone, 2001; Färe and Grosskopf, 2010). Unlike the conventional DDF, the generalized DDF that is used in this study yields efficiency scores independent of the length of the direction vector (g). Moreover, like the conventional DDF, this generalized DDF produces efficiency scores that are consistent with those obtained from radial models.

In the case where multiple technologies (e.g. k distinct technologies, where $k = 1, \dots, K$) are present, the input – desirable output – undesirable output sets are grouped into k technologically feasible sets (i.e. T^1, T^2, \dots, T^K). The collection of all input-output feasible combinations of the operational units (e.g. countries) construct the smallest convex set that is known as metatechnology set, denoted by T^{meta} (Battese and Rao, 2002; Battese et al., 2004; O'Donnell et al., 2008). The metatechnology set is modelled as follows:

$$T^{meta}(x) = \{(y, b) : x \text{ can produce } (y, b)\} \quad (4)$$

and the group-specific technology set is described as follows:

$$T^k(x) = \{(y, b) : x \text{ used by operational units in group } k \text{ can produce } (y, b)\} \quad (5)$$

Hence, $T^{meta}(x) = \{T^1(x) \cup T^2(x) \cup \dots \cup T^K(x)\}$.

By introducing the generalized DDF (Cheng and Zervopoulos, 2014) into the metatechnology framework, we measure the metaefficiency and group-specific efficiency scores as follows:

$$\vec{D}_{T^{meta}}(x^k, y^k, b^k; g_x, g_y, g_b) = \frac{1 - \frac{1}{m} \sum_{i=1}^m \beta^{meta} g_i / x_{io}^k}{1 + \frac{1}{s+p} \left(\sum_{r=1}^s \beta^{meta} g_r / y_{ro}^k + \sum_{t=1}^p \beta^{meta} g_t / b_{to}^k \right)}$$

$$s.t. \quad \sum_{k=1}^K \sum_{j=1}^n \lambda_j^k x_{ij}^k \leq x_{io}^k - \beta^{meta} g_x \quad i = 1, \dots, m$$

$$\sum_{k=1}^K \sum_{j=1}^n \lambda_j^k y_{rj}^k \geq y_{ro}^k + \beta^{meta} g_y \quad r = 1, \dots, s$$

$$\sum_{k=1}^K \sum_{j=1}^n \lambda_j^k b_{tj}^k = b_{to}^k + \beta^{meta} g_b \quad b = 1, \dots, l$$

$$\sum_{k=1}^K \sum_{j=1}^n \lambda_j^k = 1$$

$$\lambda_j^k \geq 0$$
(6)

$$\vec{D}_{T^k}(x^k, y^k, b^k; g_x, g_y, g_b) = \frac{1 - \frac{1}{m} \sum_{i=1}^m \beta^k g_i / x_{io}^k}{1 + \frac{1}{s+p} \left(\sum_{r=1}^s \beta^k g_r / y_{ro}^k + \sum_{t=1}^p \beta^k g_t / b_{to}^k \right)}$$

$$s.t. \quad \sum_{j=1}^n v_j^k x_{ij}^k \leq x_{io}^k - \beta^k g_x \quad i = 1, \dots, m$$

$$\sum_{j=1}^n v_j^k y_{rj}^k \geq y_{ro}^k + \beta^k g_y \quad r = 1, \dots, s$$

$$\sum_{j=1}^n v_j^k b_{tj}^k = b_{to}^k + \beta^k g_b \quad b = 1, \dots, l$$

$$\sum_{j=1}^n v_j^k = 1$$

$$v_j^k \geq 0, \quad k = 1, \dots, K$$
(7)

where λ_j^k and v_j^k represent the optimal weights assigned to inputs and outputs. In our case, $g_x = (1, 1, 1)$, $g_y = (1)$ and $g_b = (-1)$ as our data set consists of three inputs, one desirable output, and one undesirable output (see Fig.1).

Using programs (6) and (7), we can calculate the technology gap ratio (Battese et al., 2004) or the reciprocal relationship of the metatechnology ratio (MTR) (O'Donnell et al., 2008).

$$0 < \text{MTR}(x, y, b) = \frac{\text{MTE}(x, y, b)}{\text{TE}(x, y, b)} = \frac{\frac{1 - \frac{1}{m} \sum_{i=1}^m \beta^{meta} g_i / x_{io}^k}{1 + \frac{1}{s+p} \left(\sum_{r=1}^s \beta^{meta} g_r / y_{ro}^k + \sum_{t=1}^p \beta^{meta} g_t / b_{to}^k \right)}}{\frac{1 - \frac{1}{m} \sum_{i=1}^m \beta^k g_i / x_{io}^k}{1 + \frac{1}{s+p} \left(\sum_{r=1}^s \beta^k g_r / y_{ro}^k + \sum_{t=1}^p \beta^k g_t / b_{to}^k \right)}} \leq 1 \quad (8)$$

where MTE expresses the technical efficiency of an operational unit with respect to the metatechnology, and TE represents the technical efficiency of an operational unit with respect to the k group frontier.

The metafrontier framework provides benchmarking for all operational units independently from the group-specific frontier that each unit belongs. As a result, drawing on the technology heterogeneity concept, we can attribute differences, captured by technology gaps, due to: (a) the structure of national markets, (b) national regulations and policies, (c) cultural profiles and legal and institutional frameworks (Halkos and Tzeremes, 2011), (d) available resource endowments, (e) economic infrastructure, (f) characteristics of the physical, social and economic environment in which production takes place (O'Donnell et al., 2008; Kounetas et al., 2009), and (g) knowledge characteristics and strategic orientation (Kontolaimou and Tsekouras, 2010). In this context, a value of the MTR closer to unity indicates smaller technology heterogeneity while a value closer to zero denotes greater technology heterogeneity.

In addition to the identification of technology heterogeneity, the metatechnology framework facilitates the measurement of technology gaps (TG). Chiu et al. (2012) defined the TG inefficiency as the distance between the individual frontier and the metafrontier. The TG is obtained as follows:

$$\text{TG}(x, y, b) = \text{TE} \times (1 - \text{MTR}(x, y, b)) \quad (9)$$

We present a graphical analysis (please see Fig.1) of the world metafrontier and the two individual frontiers for the output-oriented framework. At a given input and output level, say x and y the observed country A under the non-Annex I technology consists of three components. First, the technical inefficiency (GDDE relative to the

frontier) between points A and B, the metatechnical inefficiency between points A and C (MGDDF relative to the metafrontier) and the technology gap difference denoting as TG.

3.2 The Technology Gaps' Stochastic Convergence Hypothesis

Thus we can consider technology gap (TG)³ as a continuous-time stochastic process $\{X(t), t \geq 0\}$ and assume that the each stochastic process is a continuous-time Markov chain with distribution function ϕ_t . Each X satisfies the Markovian property $\text{Prob}(X_{t+\tau} \in A | X_j, j \leq t; X = x) = \text{Prob}^\tau(x, A)$, with $A \subseteq E \subseteq \mathbb{R}$ where E is the space state of X , iP^τ called “stochastic kernel” and under certain conditions (Quah, 1997) satisfies the following equation $\phi_{t+\tau} = \int_E (x, A) \phi_t dx$ that leads to $f_{t+\tau}(y) = \int_E f_\tau(y|x) f_t(x) dx$ with $f_t(x)$ and $f_\tau(y|x)$, which are respectively the density function of ϕ_t and Prob^τ , if they exist.

The empirical estimate of the marginal probability density function (pdf) of x is given by:

$$\begin{aligned} \hat{f}(x) &= \int_{-\infty}^{+\infty} \hat{f}(x, y) dy = \frac{1}{n} \sum_{j=1}^n \frac{1}{h_x \sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-x_j}{h_x} \right)^2} \int_{-\infty}^{+\infty} \frac{1}{h_y \sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{y-y_j}{h_y} \right)^2} dy \\ &= \frac{1}{n} \sum_{j=1}^n \frac{1}{h_x \sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-x_j}{h_x} \right)^2} \end{aligned} \quad (10)$$

where the joint distribution $f(x, y)$ is obtained using a product of Gaussian kernel K (Fotopoulos, 2006):

$$\hat{f}(x, y) = \frac{1}{n} \sum_{j=1}^n \frac{1}{h_x \sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-x_j}{h_x} \right)^2} \frac{1}{h_y \sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{y-y_j}{h_y} \right)^2}$$

³ For clarity and presentation reasons we consider TG as X .

$$= \frac{1}{n} \sum_{j=1}^n \frac{1}{h_x} K\left(\frac{x-x_j}{h_x}\right) \frac{1}{h_y} K\left(\frac{y-y_j}{h_y}\right) \quad (11)$$

where h_x and h_y are bandwidths calculated with the direct plug method applied separately in each dimension. In this way, a nonparametric estimation of the stochastic kernel⁴ is given by:

$$\hat{f}_\tau(y|x) = \frac{\hat{f}(y, x)}{\hat{f}(x)} \quad (12)$$

The stochastic kernel may be interpreted as a transition matrix with a continuum of rows and columns. Let a time interval of length τ ; the relationship among two distributions over τ can be written as:

$$f_{t+\tau}(y) = \int_{-\infty}^{+\infty} f_\tau(y|x) f_t(x) dx \quad (13)$$

Following the approach developed by Johnson (2000 and 2005) and Fotopoulos (2006), the long-run ergodic distribution is found as the solution to:

$$f_\infty(y) = \int_{-\infty}^{+\infty} f_\tau(y|x) f_\infty(x) dx \quad (14)$$

One possible way to face this problem is through a discretization of the time interval $[\alpha, b]$ by partitioning it in n non-overlapping subintervals, then is possible to estimate $f_\tau(z_j|x_i)$ with z_j, x_i midpoints of these subintervals. If $p_{ij} = f_\tau(z_j|x_i) \frac{b-a}{n}$ (≥ 0) are defined and n is sufficiently large (which leads to $\sum_{j=1}^n f_\tau(z_j|x) \frac{b-a}{n} \approx 1$) then the $n \times n$ matrix $\mathbf{P} = \{p_{ij}\}$ has the same structure as a transition probabilities matrix and $\{p_{ij}\}_{j=1}^n$ may be seen as the conditional probability mass function. The ergodic density can be evaluated as $f_\infty(y) = \psi \mid \frac{b-a}{n}$, where ψ is the rescaled (unit

⁴ In general, the characteristics of the kernel function and bandwidths influence the quality of the density estimation. Different kernel alternatives may be used (Silverman 1986, Wand and Jones 1995). Since the kernel estimator is not very sensitive to a choice of K , a Gaussian kernel has been used (Magrini 2007). Moreover, the Mean Integrated Squared Error (MISE) is minimized by a multivariate standard normal density over the class of product kernels (Pagan and Ullah 1999).

sum) left eigenvector corresponding to the unity eigenvalue (also the largest one) of the matrix P .

4. Data Sources and Variable Definitions

To investigate the issues surrounding our main research question we have devised a unique dataset by employing and matching distinct, but complementary, information sources. The resulting dataset is a balanced panel consisting of 103 countries for the 1995-2011 period and our final panel dimension comprises of 1751 observations. We should note that our sample is affected by the events of the global financial crisis that manifested from August 2007 onwards but also covers the period before and after Kyoto's implementation. It is worth adding that the sample period was chosen purely on the basis of availability of key variables, some of which become unavailable after 1995.

For the estimation of productive efficiency with respect to each country frontier and the specific metafrontier as well, we employ a multi-input – single-desirable output- single-undesirable output data set. More specifically, we approximate the output variable (Y) by the Gross Value Added of each industry as the desirable output and CO2 emissions in metric tonnes (Mt) as the undesirable one. For the input side, we include the capital stock (K) in million Dollars, the labor input (L) which is captured by the total hours worked by employees, expenditure on intermediate inputs (M) in million Dollars and the total energy consumption (E) measured in million tons (Mt) of oil equivalent. Table 1 provides the definition, measurement and basic descriptive statistics for each variable.

As already mentioned, the data were drawn by combining several distinct sources of information. Data for Gross Value Added, total hours worked by employees and

intermediate inputs were obtained from the World Bank database (World Bank Developing Indicators), Enerdata-Odyssey database was used to collect data on energy consumption and CO₂. Finally, data on capital were acquired through OECD Structural Analysis and World Bank databases respectively. The deflators used to convert the current into constant 2005 prices are specific to each country. At this point, we should mention that the distinction in two specific frontiers (AnnexI and non-AnnexI) has been held following the distinction of Kyoto's protocol.

5. Empirical Results and Discussion

The presentation and discussion of the empirical results follows the two stage structure of the methodology section. The country specific efficiency scores with respect to the two groups are firstly presented and discussed. Subsequently, the metatechnology efficiency scores, the associated metatechnology ratios and technology gaps which arises in the context of the metafrontier have been used for the examination of our hypothesis. At the end, the results from the estimation of the stochastic kernel for the technology gaps has been presented.

5.1 Efficiency, Metatechnology ratios and Technology Gap Estimates

Productive efficiency scores with respect to the specific technology and the metatechnology, the associated metatechnology ratios and technological gaps are estimated for the 103 countries in each of the 17 years. GAMS is used to solve the linear problem of the generalized distance function expanding its use in also the metatechnology (Cheng and Zervopoulos, 2014). At this point, it is crucial to note that both the productive efficiency and technology gap estimations are grounded on a cross-section basis, estimated separately for each year in the sample denoting an

individual production set. Therefore, the values of the estimated productive efficiency and technology gap for each country encompass two dynamic factors. First is the change of the distance from the (meta-) frontier, while the second is the movement outwards (technical change) or inwards (technical regress) of the metafrontier itself. Using this logic, the estimated time-series for efficiency and technology gaps reflect the diachronic evolution of productive performance of the examined country, considering any technological developments either in the industry-specific frontier or in the metatechnology.

Mean values of productive efficiency for each frontier, the metafrontier and the associated technology gaps are calculated in Table 3. The sample average of metatechnical efficiency is 0.827. This implies that countries operate at the average values of outputs and inputs have the potential to increase their GDP and simultaneously, decrease their CO₂ emissions by about 17.3%. Furthermore, it is quite interesting to mention the slightly difference between AnnexI and non-AnnexI countries regarding their efficiency performance (0.886 against 0.847) with respect to their frontier but also the significant difference for their performance with respect to their metafrontier (0.878 against 0.799). The same holds for technology gaps with the corresponding values to be 0.029 for the AnnexI and 0.167 for the non-AnnexI. Furthermore, a Kruskal-Wallis test has been applied to examine the technology frontier differences between the AnnexI, non-AnnexI countries. The result shows that the value of this test is 203.17 and thus, the two groups have distinct technology frontiers with respect to their meta-efficiency productive performance.

Tables 4 and 5 display the estimated values of (i) the productive efficiency with respect to the specific technology and (ii) the technology gap with respect to the Global metatechnology for each country between 1995-2011. The distributions of the

productive efficiency are also given in Fig.2 which shows kernel density estimates for the first period of the sample (1995), two middle periods (2000 and 2005), and the last (2011). Furthermore, the time evolution of metatechnology ratios for the two groups and the total sample are depicted in Fig.3.

We begin by looking at the estimated productive efficiency and technology gap values for Annex-I countries. From our results it is clear that countries like Germany, France, the Czech Republic, Ireland, Latvia, the Netherlands, New Zealand, Slovenia, Sweden Turkey, UK and USA exhibit the highest scores for productive efficiency constructing the Champions group, while Bulgaria, Belarus, Croatia and Hungary perform the worst (the laggards group). Furthermore, examining the efficiency scores with respect to the metatechnology, Canada, France, Ireland, Italy, Japan, Malta, Norway, Turkey, UK and USA present the smallest technology gaps and constitute, diachronically, the metafrontier. In contrast, a group of countries like Lithuania, Latvia, Poland, Portugal, Romania, Slovakia, and Ukraine perform worst among the remaining ones suggesting that significant knowledge spillover effects are not in operation within country-specific technologies. Latvia and New Zealand interestingly, though a champion under the AnnexI frontier, also maintain a large technology gap, suggesting some strong allocative inefficiencies.

Shifting attention towards to the non-AnnexI technological frontier given in Table 5, the sample average productive efficiency scores reveal that Armenia, China, Hong-Kong, Egypt, Mexico, Singapore and South Korea perform identically on average. However, it is quite interesting that only 4 of 66 (6.02%) of them diachronically define the metafrontier. Indonesia, Iran, Philippines and Singapore define the metafrontier more often than any other counterpart whilst Armenia, Georgia, MDA and Cambodia significantly underperform. The corresponding results

accompanied from the significant low TGs scores for the specific group support the idea of significant knowledge incoming spillover barriers from the metatechnology (Tsekouras et al. 2016). Possible explanations arises from the specific nature of the agreement for non-Annex I countries (Böhringer and Vogt, 2003; 2004), the role of appropriability conditions (Castellaci, 2007), the degree of openness to foreign competition, mainly via globalization, the assymetric effect of technological opportunities and the size of the market (Los and Verspagen, 2006).

The time evolution of the productive efficiency scores, using the corresponding kernel densities, for the total sample, depicted in Fig.2c, reflect a process of continuous and quite significant divergence only for the 2011 period. This is reflected in the increased deviation of the distribution. The specific result provides valuable information for the impact of the Kyoto protocol on environmental performance since 2011 is only one year from its expiration. On the other hand, it is quite interesting the small but noticeable deterioration in 2005 year during the Kyoto transition period. The corresponding time evolution of the AnnexI (Fig.2a) reveals that, although the overall picture is quite similar to the one sketched for the total sample, a significant increase of the productive efficiency scores were especially significant during the period. Fig.2b offers the time evolution of the productive efficiency scores of the non-Annex I group. Notwithstanding this, the distribution remains almost steady with no apparent divergence or convergence processes in operation.

Finally, the box-plots of diachronic performance of metatechnology ratios provide more insight into the distribution among AnnexI, non-AnnexI and the total sample. In Fig.3c a box plot graph of the estimated metatechnology ratios of the total sample is depicted. It is evident that metatechnology ratios as well as their deviations

are diachronically constant with no significant fluctuations. It is clear that Annex-I countries yield the best average and variance of metatechnology ratios compared with non-Annex-I and the total sample with a distribution skewed to the right (see Fig.3a). Moreover, the metatechnology ratios slightly decrease in the 2002-2005 period but exhibit a drastic increase over the 2005-2011. In contrast, Fig.3b mirrors a rather different, compared to the AnnexI case, pattern of the non-AnnexI metatechnology ratios performance. More specifically, it seems that between 1995 and 2001 technology gaps remain quite distant while for the 2002-2008 period a significant decrease has occurred. On the contrary, in the time window from 2009 to 2011, a considerable increase emerged. In the same direction, but more impressive, is the picture of the total sample metatechnology ratios distribution presented in Fig.3c.

5.2 Stochastic Kernel of Annex I and non-Annex I Technology Gaps

The non parametric methodology of stochastic kernel adopted in this study, refers to the “convergence literature”, typified by the seminal papers by Barro and Sala-i-Martin (1991) and Mankiw et al. (1992) exploring beta-convergence. However, according to Quah (1993) stochastic Kernels describes the law of motion of a sequence of distribution and it serves to retrieve the evolution of the probability distribution of a random variable (usually GDP) along time allowing it to overcome the limitations of conventional convergence analysis focus on the dynamic properties of the series. Stochastic Kernel (Quah, 1996, 1997) resulted in the literature from the necessity to substitute discrete transition matrices. In this way, stochastic kernels can be achieved by estimating the density function of a distribution over a given period, let's say $t+k$, conditioned on the values corresponding to a previous period, t .

We examine the convergence-divergence hypothesis for technology gaps. The stochastic kernel in Fig.4 shows how countries' technological gaps in 1995 evolves into 2011. Thus, over the 17 years, a three peaks property appears. Each specific peak reflects a comparatively substantial number of observed transitions from a part of the distribution to another while having a constant point x-axis. We can understand the estimated distribution of technology gaps in 2011 at its initial level in 1995. A large portion of the probability mass is concentrated along the 45° diagonal while the existence of three peaks along the diagonal indicates the presence of individual convergence clubs for all the 103 countries. More specifically, there are two local maxima in both low and high technological gaps parts and a third in the middle part of relative ones.

Considering the corresponding contour plot in Fig.5, we notice that during the examined period, countries have a low probability of changing their relative position in one year in terms of technological gaps suggesting that the mobility is low. The three peaks phenomenon for technological gaps directly links productivity differentials and technology structure. This could be further explained in terms of factor accumulation deformations, factor prices change that acts as an inducement for the introduction of new technologies (Binswanger et al., 1978) and localized technological change (Antonelli, 2006; Mulder and DeGroot, 2012). Factor accumulation distortions (Easterly and Levine, 2001) of the examined countries in both physical and in terms of human capital could be important to facilitate the objective of the three clubs creation. For instance, physical capital investment may embody new energy saving technologies to help in catching up the frontier but this is not the case for all countries.

6. Conclusions

Addressing the problems arising from GHGs emissions released in the environment and climate change calls for a better understanding of the patterns of CO₂ emissions and country efficiency performance over time. The Kyoto Protocol which imposes emissions reduction targets on industrialized countries, has been celebrated as a milestone in climate protection and mitigation for the world community. In this study, we apply a generalized efficiency measure of a directional distance function that allows the directional vector to be independent of the length, under a metafrontier framework. A particular, however, emphasis is on the construction of a best practice metafrontier production function that allows for the comparison of two individual frontiers (Annex I and non-Annex I countries) with completely different technological regimes.

It has been found that, on average, countries of Annex I group achieved highest values of productive efficiency and meta-efficiency performance compared with non-Annex I group frontier. Among the countries, Canada, France, Ireland, Italy, Japan, Malta, Norway, Turkey, UK and USA seem to perform best in their frontier and metafrontier. In addition, only four countries, Indonesia, Iran, Philippines and Singapore, report the same for the non-Annex I countries case.

Moreover, the results with respect to technological gaps report a rather enlarged differentiation for the two groups. The specific differentiation seems to acquire a timeless character with completely different behaviors in the two clusters. The significantly different behavior of the two clusters, in terms of technological gaps, could strongly depend on differences in local capabilities and on consequential technologically and environmental spillovers arising from the metafrontier production

function. Causes of the different behavior of the two frontiers would benefit from further investigation.

The information yielded investigating the convergence hypothesis with respect to technological gaps reveals the significant role of spillovers and its inner-flows not only for each country but also for the two groups. Furthermore, it is related with general factors as different national policies, level of technology, the ambiguity of the role of internationalization and lax regulation.

Finally, it should be noted that the results of our study are dependent on the countries included and the variables used. Further research may be carried out to extend this study by covering a greater number of countries with a larger period of examination. Moreover, it is interesting to examine the possible drivers responsible for the different groups behavior with respect to their productive performance and technology gap characteristics.

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APPENDIX A

Table 1: Variables, units of measurement and sources

Variable	Units of measurement	Source
Output (Y)	million \$	World Bank
Capital (K)	million \$	OECD STAN, World Bank
Labor (L)	million hours worked by employees	World Bank
CO₂ emissions (CO₂)	million \$	Enerdata - Odyssey
Energy consumption (E)	million tons of oil equivalent	Enerdata - Odyssey
All the values are in constant 2005 prices.		

Table 2: Descriptive statistics by type of agreement and variable

	TOTAL	Annex-I	Non-Annex-I
<i>Y</i>	203,81 (143,1)	125,16 (185,41)	14,64 (18,87)
<i>K</i>	1575,85 (4561,07)	745,14 (658,1)	55,48 (98,49)
<i>L</i>	24,05 (84,06)	12,83 (24,17)	3,91 (4,97)
<i>CO₂</i>	231,441 (731,35)	168,15 (125,17)	89,25 (63,25)
<i>E</i>	93,125 (281,76)	65,47 (58,62)	22,01 (17,32)

Note 1: Numbers indicate the mean value while parentheses correspond to the standard deviation

Table 3: Average descriptive statistics for technical, metatechnical efficiency and technology gaps for the individual groups

	Technical Efficiency	Meta-technical Efficiency	Technology Gap
Annex-I	0.886 (0.102)	0.878 (0.107)	0.029 (0.011)
Non-Annex-I I	0.849 (0.125)	0.799 (0.122)	0.167 (0.103)
ALL	0.869 (0.118)	0.827 (0.122)	0.077 (0.032)

Table 4: Productive Efficiency scores and Technology gap values for the Annex I countries to the Kyoto convention for 1995-2011

Country		AUS	AUT	BEL	BUL	BLR	CAN	CHE	CYP	CRO	CZE	DEN	ESP	EST	FIN	FRA	GER	GRC	HUN	IRL	ICE	ITA
1995	TE	0.927	0.884	0.924	0.730	0.705	1.000	1.000	0.917	0.778	0.773	0.863	0.955	0.764	0.861	1.000	1.000	0.812	0.766	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.011	0.017	0.000	0.000	0.007	0.010	0.000	0.009	0.000	0.009	0.018	0.000	0.004	0.002	0.000	0.000	0.000	0.000
1996	TE	0.926	0.880	0.917	0.720	0.706	1.000	1.000	0.913	0.772	0.774	0.862	1.000	0.770	0.860	1.000	1.000	0.811	0.764	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.011	0.013	0.000	0.000	0.008	0.009	0.001	0.008	0.014	0.012	0.015	0.000	0.004	0.002	0.000	0.000	0.000	0.000
1997	TE	0.930	0.876	0.918	0.718	0.709	1.000	1.000	0.912	0.774	0.771	0.861	0.948	0.776	0.860	1.000	1.000	0.813	0.764	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.019	0.023	0.000	0.076	0.015	0.012	0.009	0.010	0.001	0.023	0.019	0.000	0.006	0.005	0.000	0.000	0.000	0.000
1998	TE	0.932	0.883	0.917	0.720	0.712	1.000	1.000	0.914	0.779	0.773	0.862	0.950	0.779	0.866	1.000	1.000	0.813	0.767	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.023	0.029	0.000	0.000	0.026	0.015	0.029	0.013	0.001	0.025	0.022	0.000	0.008	0.004	0.000	0.000	0.000	0.000
1999	TE	0.932	0.886	0.919	0.723	0.713	1.000	1.000	0.915	0.781	0.776	0.862	0.945	0.778	0.866	1.000	1.000	0.815	0.766	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.024	0.032	0.000	0.000	0.025	0.015	0.022	0.005	0.000	0.018	0.022	0.000	0.008	0.007	0.000	0.000	0.000	0.000
2000	TE	0.923	0.886	0.916	0.727	0.714	1.000	1.000	0.917	0.779	0.779	0.863	0.937	0.791	0.867	1.000	1.000	0.817	0.766	1.000	0.989	1.000
	TG	0.000	0.000	0.000	0.026	0.036	0.000	0.000	0.026	0.016	0.037	0.003	0.001	0.029	0.023	0.000	0.009	0.006	0.001	0.000	0.000	0.000
2001	TE	0.928	0.881	0.910	0.729	0.716	1.000	1.000	0.925	0.791	0.781	0.860	0.939	0.797	0.866	1.000	1.000	0.820	0.769	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.028	0.039	0.000	0.000	0.024	0.016	0.027	0.004	0.002	0.035	0.024	0.000	0.009	0.008	0.000	0.000	0.000	0.000
2002	TE	0.927	0.882	0.910	0.731	0.719	1.000	1.000	0.923	0.792	0.782	0.859	0.935	0.800	0.866	1.000	1.000	0.820	0.772	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.031	0.043	0.000	0.000	0.027	0.018	0.031	0.011	0.000	0.038	0.027	0.000	0.010	0.004	0.000	0.000	0.000	0.000
2003	TE	0.928	0.877	0.907	0.732	0.722	0.986	1.000	0.918	0.796	0.784	0.858	0.941	0.804	0.866	1.000	1.000	0.823	0.774	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.030	0.033	0.000	0.000	0.025	0.017	0.032	0.010	0.001	0.034	0.026	0.000	0.009	0.008	0.000	0.000	0.000	0.000
2004	TE	0.924	0.873	0.904	0.733	0.726	0.977	1.000	0.915	0.796	0.786	0.858	0.930	0.807	0.866	1.000	1.000	0.821	0.777	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.036	0.036	0.000	0.000	0.025	0.021	0.023	0.010	0.001	0.042	0.032	0.000	0.012	0.021	0.000	0.000	0.000	0.000
2005	TE	0.919	0.872	0.901	0.734	0.730	0.970	1.000	0.910	0.799	0.790	0.859	0.927	0.811	0.867	1.000	1.000	0.818	0.781	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.032	0.024	0.000	0.000	0.022	0.019	0.020	0.005	0.000	0.029	0.029	0.000	0.009	0.017	0.000	0.000	0.000	0.000
2006	TE	0.921	0.880	0.906	0.737	0.736	0.963	1.000	0.911	0.807	0.798	0.864	0.930	0.813	0.874	1.000	1.000	0.826	0.786	1.000	1.000	1.000
	TG	0.000	0.000	0.000	0.038	0.024	0.000	0.000	0.022	0.024	0.023	0.011	0.000	0.030	0.036	0.000	0.010	0.012	0.000	0.000	0.000	0.000
2007	TE	0.922	0.888	0.911	0.739	0.742	0.949	1.000	0.913	0.811	0.805	0.866	0.924	0.821	0.884	1.000	1.000	0.832	0.788	1.000	1.000	0.988
	TG	0.000	0.000	0.000	0.033	0.015	0.000	0.000	0.017	0.022	0.017	0.006	0.000	0.022	0.036	0.000	0.009	0.009	0.000	0.000	0.000	0.000
2008	TE	0.919	0.895	0.916	0.744	0.750	0.945	1.000	0.924	0.819	0.811	0.870	0.940	0.817	0.888	1.000	1.000	0.836	0.797	1.000	1.000	0.990
	TG	0.000	0.001	0.002	0.024	0.012	0.000	0.000	0.017	0.022	0.025	0.005	0.001	0.025	0.033	0.000	0.013	0.007	0.000	0.000	0.001	0.000
2009	TE	0.923	0.891	0.912	0.742	0.753	0.936	1.000	0.932	0.817	0.809	0.866	0.959	0.817	0.879	1.000	1.000	0.834	0.794	1.000	1.000	0.983
	TG	0.000	0.001	0.005	0.023	0.014	0.000	0.000	0.021	0.022	0.025	0.011	0.002	0.018	0.036	0.000	0.018	0.001	0.000	0.000	0.001	0.000
2010	TE	0.923	0.892	0.913	0.745	0.757	0.928	1.000	0.936	0.819	0.812	0.870	1.000	0.828	0.882	1.000	1.000	0.832	0.794	1.000	1.000	0.988
	TG	0.006	0.001	0.011	0.029	0.020	0.000	0.000	0.024	0.026	0.026	0.016	0.041	0.020	0.057	0.000	0.030	0.000	0.000	0.000	0.003	0.000
2011	TE	0.919	0.895	0.914	0.747	0.758	0.916	1.000	0.936	0.822	0.812	0.865	0.974	0.823	0.878	1.000	1.000	0.828	0.791	1.000	1.000	0.983
	TG	0.003	0.011	0.039	0.032	0.022	0.001	0.000	0.027	0.040	0.026	0.021	0.021	0.021	0.066	0.000	0.042	0.000	0.000	0.000	0.005	0.000
	Mean TE	0.925	0.884	0.913	0.732	0.728	0.975	1.000	0.919	0.796	0.789	0.863	0.949	0.800	0.870	1.000	1.000	0.822	0.777	1.000	0.999	0.996
	Mean TG	0.001	0.001	0.003	0.026	0.025	0.000	0.004	0.021	0.019	0.022	0.009	0.005	0.025	0.031	0.000	0.012	0.007	0.000	0.000	0.001	0.000
																					St.De	
		JAP	LTU	LUX	LAT	MAL	NLD	NOR	NZL	POL	POR	ROM	SVK	SVN	SWE	TUR	UKR	UK	USA	Mean	v	

1995	TE	1.000	0.739	1.000	0.736	1.000	0.938	1.000	0.823	0.758	0.794	0.711	0.762	0.795	0.851	1.000	0.699	1.000	1.000	0.879	0.111
	TG	0.000	0.261	0.000	0.264	0.000	0.062	0.000	0.177	0.242	0.206	0.289	0.238	0.205	0.149	0.000	0.301	0.000	0.000	0.064	0.104
1996	TE	0.997	0.989	1.000	1.000	1.000	1.000	0.987	1.000	0.998	0.998	0.978	0.992	1.000	1.000	1.000	1.000	1.000	1.000	0.939	0.095
	TG	0.000	0.257	0.000	0.261	0.000	0.067	0.000	0.182	0.240	0.207	0.288	0.236	0.199	0.152	0.000	0.305	0.000	0.000	0.064	0.104
1997	TE	0.996	0.989	1.000	1.000	1.000	1.000	0.986	1.000	0.997	0.998	0.979	0.990	1.000	1.000	1.000	1.000	1.000	1.000	0.938	0.094
	TG	0.000	0.253	0.000	0.260	0.000	0.068	0.000	0.182	0.236	0.208	0.289	0.233	0.193	0.150	0.000	0.306	0.000	0.000	0.067	0.102
1998	TE	0.994	0.980	0.998	1.000	1.000	1.000	0.973	1.000	0.996	0.997	0.966	0.976	1.000	1.000	1.000	0.999	1.000	1.000	0.937	0.092
	TG	0.000	0.247	0.000	0.257	0.000	0.064	0.000	0.180	0.234	0.205	0.289	0.228	0.190	0.145	0.000	0.306	0.000	0.000	0.065	0.101
1999	TE	0.989	0.968	0.987	1.000	1.000	1.000	0.963	1.000	0.995	0.996	0.957	0.967	1.000	1.000	1.000	0.999	1.000	1.000	0.936	0.091
	TG	0.000	0.247	0.000	0.255	0.000	0.047	0.000	0.176	0.227	0.203	0.288	0.227	0.188	0.141	0.000	0.306	0.000	0.000	0.064	0.100
2000	TE	0.996	0.975	0.987	1.000	1.000	1.000	0.955	1.000	0.996	0.995	0.954	0.966	1.000	1.000	1.000	0.999	1.000	1.000	0.936	0.090
	TG	0.000	0.242	0.000	0.248	0.000	0.050	0.000	0.181	0.223	0.204	0.288	0.226	0.187	0.141	0.000	0.304	0.000	0.000	0.064	0.099
2001	TE	0.995	0.980	0.977	1.000	1.000	1.000	0.958	1.000	0.996	0.994	0.948	0.972	1.000	1.000	1.000	0.998	1.000	1.000	0.937	0.088
	TG	0.000	0.231	0.000	0.243	0.000	0.056	0.000	0.181	0.221	0.205	0.285	0.223	0.183	0.147	0.000	0.302	0.000	0.000	0.064	0.098
2002	TE	0.989	0.970	0.964	1.000	1.000	1.000	0.950	1.000	0.995	0.994	0.945	0.956	1.000	1.000	1.000	0.999	1.000	1.000	0.935	0.087
	TG	0.000	0.229	0.000	0.241	0.000	0.068	0.000	0.180	0.217	0.206	0.278	0.219	0.182	0.140	0.000	0.301	0.000	0.000	0.064	0.096
2003	TE	0.986	0.962	0.957	1.000	1.000	1.000	0.946	1.000	0.995	0.993	0.939	0.953	1.000	1.000	1.000	0.999	1.000	1.000	0.935	0.086
	TG	0.000	0.221	0.000	0.237	0.000	0.071	0.000	0.181	0.213	0.209	0.276	0.217	0.179	0.131	0.000	0.299	0.000	0.000	0.063	0.095
2004	TE	0.990	0.985	0.958	1.000	1.000	1.000	0.957	1.000	0.994	0.994	0.942	0.964	1.000	1.000	1.000	1.000	1.000	1.000	0.935	0.086
	TG	0.000	0.215	0.000	0.235	0.000	0.074	0.000	0.186	0.211	0.211	0.272	0.215	0.177	0.122	0.000	0.295	0.000	0.000	0.063	0.094

2005	TE	0.991	0.987	0.940	1.000	0.999	1.000	0.960	1.000	0.992	0.993	0.942	0.965	1.000	1.000	1.000	1.000	1.000	1.000	0.935	0.085
	TG	0.000	0.208	0.000	0.229	0.000	0.069	0.000	0.188	0.211	0.211	0.269	0.210	0.173	0.000	0.000	0.295	0.000	0.000	0.058	0.093
2006	TE	0.994	0.991	0.957	1.000	0.998	1.000	0.972	1.000	0.992	0.994	0.957	0.974	1.000	1.000	1.000	1.000	1.000	1.000	0.938	0.083
	TG	0.000	0.200	0.000	0.224	0.000	0.058	0.000	0.187	0.206	0.208	0.263	0.202	0.167	0.000	0.000	0.291	0.000	0.000	0.057	0.091
2007	TE	0.995	0.991	0.957	1.000	0.998	1.000	0.971	1.000	0.989	0.993	0.956	0.973	1.000	1.000	1.000	1.000	1.000	1.000	0.939	0.081
	TG	0.000	0.192	0.000	0.217	0.000	0.058	0.000	0.183	0.202	0.202	0.258	0.190	0.161	0.000	0.000	0.287	0.000	0.000	0.055	0.089
2008	TE	0.997	0.994	0.982	1.000	0.998	1.000	0.979	1.000	0.990	0.994	0.972	0.984	1.000	1.000	1.000	1.000	1.000	1.000	0.942	0.079
	TG	0.000	0.185	0.000	0.219	0.000	0.047	0.000	0.180	0.190	0.197	0.249	0.181	0.153	0.000	0.000	0.284	0.000	0.000	0.053	0.087
2009	TE	0.997	0.996	0.972	1.000	0.998	1.000	0.975	1.000	0.993	0.993	0.970	0.977	1.000	1.000	1.000	0.998	1.000	1.000	0.941	0.079
	TG	0.000	0.198	0.005	0.218	0.000	0.059	0.000	0.174	0.181	0.194	0.251	0.181	0.157	0.000	0.000	0.290	0.000	0.000	0.054	0.087
2010	TE	0.994	0.993	0.961	1.000	0.999	1.000	0.977	1.000	0.990	0.990	0.970	0.976	1.000	1.000	1.000	0.997	1.000	1.000	0.943	0.078
	TG	0.000	0.191	0.009	0.214	0.000	0.059	0.000	0.176	0.178	0.191	0.252	0.175	0.153	0.000	0.000	0.289	0.000	0.000	0.056	0.085
2011	TE	0.991	0.989	0.952	1.000	0.995	1.000	0.976	1.000	0.992	0.983	0.961	0.973	1.000	1.000	1.000	0.993	1.000	1.000	0.940	0.078
	TG	0.000	0.190	0.020	0.200	0.000	0.057	0.000	0.182	0.176	0.194	0.251	0.177	0.155	0.000	0.000	0.286	0.000	0.000	0.058	0.083
		0.993	0.984	0.972	1.000	0.999	1.000	0.968	1.000	0.994	0.994	0.959	0.972	1.000	1.000	1.000	0.999	1.000	1.000		
	Mean TE	0.000	0.222	0.002	0.237	0.000	0.061	0.000	0.181	0.212	0.204	0.273	0.210	0.177	0.083	0.000	0.297	0.000	0.000		
	Mean TG																				

Table 5: Productive Efficiency scores and Technology gap values for the non-AnnexI countries to the convention for 1995-2011

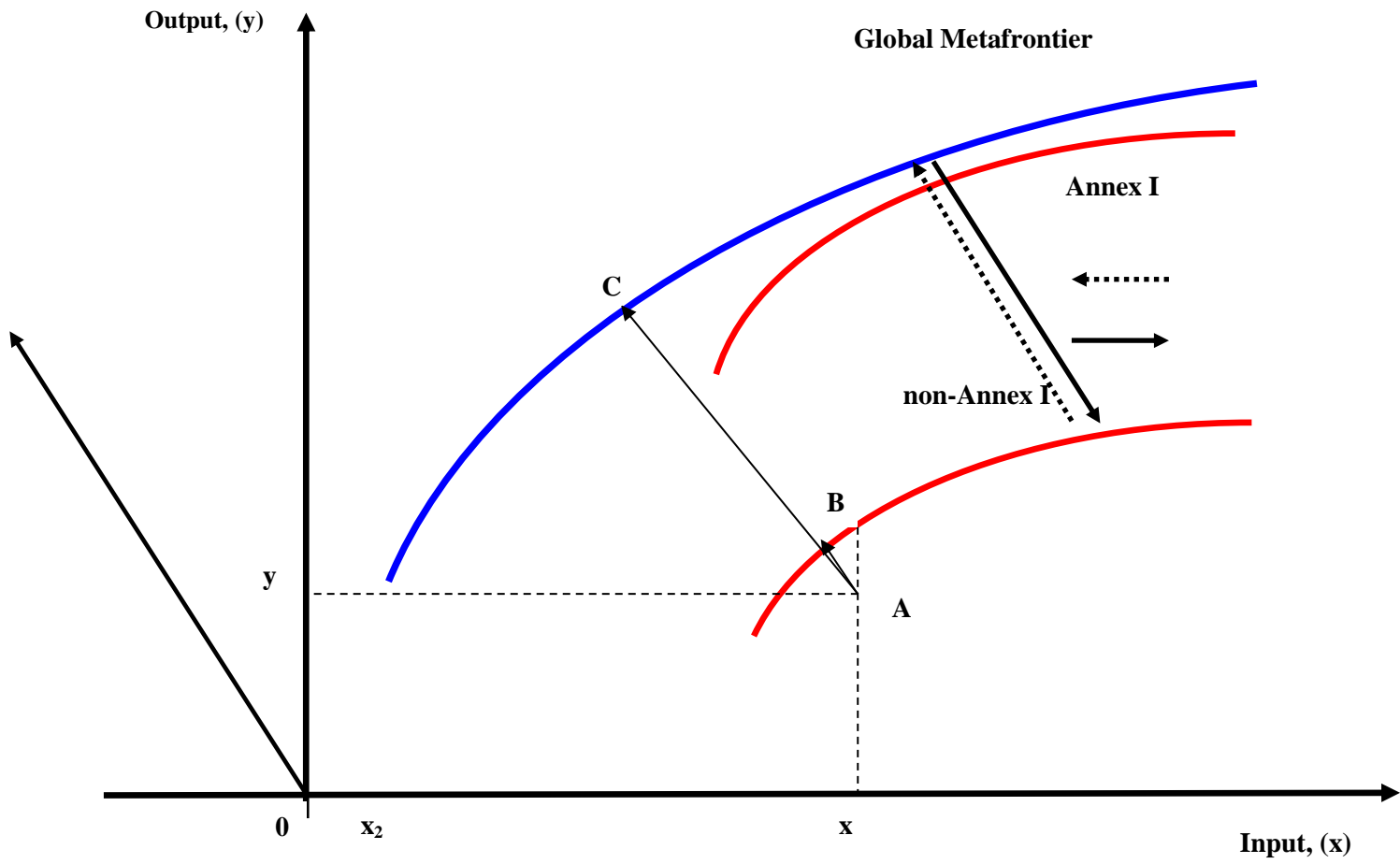
		ALB	ANG	ARG	ARM	AZR	BNG	BAH	BOL	BRA	CHL	CHN	CAM	COL	CRI	DOM	ECU	EGY	ETH	GEO	GHA	HK	IDN
1995	TE	0.956	0.682	0.780	1.000	0.700	0.703	1.000	0.775	1.000	1.000	1.000	0.738	0.751	0.956	0.776	0.739	1.000	1.000	0.878	0.720	1.000	0.767
	TG	0.000	0.001	0.027	0.303	0.023	0.095	0.039	0.095	0.000	0.075	0.254	0.312	0.032	0.000	0.067	0.027	0.000	0.000	0.211	0.066	0.054	0.000
1996	TE	0.967	0.684	0.786	1.000	0.700	0.705	1.000	0.785	1.000	1.000	1.000	0.737	0.749	0.988	0.780	0.738	1.000	1.000	0.844	0.718	1.000	0.750
	TG	0.000	0.000	0.032	0.301	0.024	0.105	0.042	0.106	0.000	0.073	0.252	0.311	0.034	0.000	0.072	0.027	0.000	0.000	0.213	0.170	0.052	0.000
1997	TE	0.987	0.685	0.794	1.000	0.701	0.711	1.000	0.767	0.749	0.991	1.000	1.000	0.752	1.000	0.765	0.750	1.000	0.703	0.839	0.714	1.000	0.737
	TG	0.000	0.000	0.033	0.300	0.027	0.126	0.050	0.089	0.005	0.000	0.244	0.311	0.035	0.000	0.060	0.046	0.000	0.022	0.218	0.165	0.048	0.000
1998	TE	0.995	0.684	0.799	1.000	0.703	1.000	1.000	0.770	0.746	0.932	1.000	1.000	0.754	1.000	0.757	0.743	1.000	0.682	0.848	0.712	1.000	0.700
	TG	0.000	0.000	0.036	0.298	0.029	0.132	0.324	0.096	0.005	0.000	0.197	0.311	0.040	0.000	0.055	0.039	0.000	0.018	0.222	0.172	0.045	0.000
1999	TE	1.000	0.684	0.791	1.000	0.704	1.000	1.000	0.769	0.743	0.865	1.000	1.000	0.749	1.000	0.776	0.753	1.000	0.696	0.866	0.714	1.000	0.697
	TG	0.151	0.001	0.035	0.296	0.030	0.137	0.324	0.096	0.005	0.000	0.139	0.310	0.040	0.000	0.074	0.052	0.000	0.023	0.220	0.185	0.048	0.000
2000	TE	1.000	0.683	0.785	1.000	0.704	1.000	1.000	0.768	0.742	0.864	1.000	1.000	0.743	1.000	0.767	0.751	1.000	0.677	0.847	0.712	1.000	0.698
	TG	0.271	0.001	0.034	0.295	0.029	0.138	0.324	0.096	0.006	0.000	0.138	0.309	0.036	0.000	0.070	0.053	0.000	0.013	0.219	0.172	0.047	0.000
2001	TE	1.000	0.683	0.779	1.000	0.704	1.000	1.000	0.788	0.743	0.910	1.000	1.000	0.742	1.000	0.765	0.733	1.000	0.773	0.835	0.712	1.000	0.702
	TG	0.000	0.003	0.037	0.293	0.029	0.130	0.056	0.111	0.007	0.000	0.184	0.308	0.037	0.000	0.060	0.032	0.000	0.021	0.217	0.156	0.047	0.000
2002	TE	1.000	0.685	0.776	1.000	0.704	1.000	1.000	0.778	0.742	0.860	1.000	1.000	0.742	1.000	0.772	0.726	1.000	0.733	0.894	0.714	1.000	0.707
	TG	0.258	0.007	0.038	0.284	0.027	0.110	0.055	0.104	0.007	0.000	0.139	0.306	0.037	0.000	0.069	0.027	0.000	0.013	0.216	0.208	0.050	0.000
2003	TE	1.000	0.684	0.780	1.000	0.703	0.717	1.000	0.765	0.741	0.922	1.000	1.000	0.739	1.000	0.780	0.725	1.000	0.716	0.889	0.717	1.000	0.709
	TG	0.255	0.001	0.040	0.264	0.022	0.079	0.058	0.091	0.006	0.000	0.197	0.304	0.032	0.000	0.077	0.025	0.000	0.027	0.211	0.189	0.053	0.000
2004	TE	1.000	0.685	0.778	1.000	0.703	0.699	1.000	0.770	0.740	0.902	1.000	1.000	0.737	1.000	0.781	0.721	1.000	0.729	0.893	0.718	1.000	0.708
	TG	0.253	0.008	0.038	0.212	0.024	0.077	0.034	0.097	0.006	0.000	0.179	0.302	0.032	0.000	0.078	0.022	0.249	0.012	0.208	0.203	0.055	0.000
2005	TE	1.000	0.687	0.781	1.000	0.719	0.698	1.000	0.764	0.739	0.893	1.000	1.000	0.734	1.000	0.796	0.724	1.000	1.000	0.874	0.738	1.000	0.709
	TG	0.250	0.005	0.038	0.179	0.030	0.084	0.031	0.093	0.006	0.000	0.168	0.300	0.028	0.000	0.091	0.024	0.256	0.000	0.205	0.181	0.078	0.000
2006	TE	1.000	0.691	0.782	1.000	0.809	0.680	1.000	0.747	0.739	0.830	1.000	1.000	0.737	1.000	0.801	0.725	1.000	1.000	0.862	0.713	1.000	0.709
	TG	0.234	0.007	0.033	0.141	0.116	0.114	0.006	0.075	0.006	0.000	0.108	0.296	0.022	0.000	0.092	0.021	0.252	0.000	0.203	0.166	0.047	0.000
2007	TE	1.000	0.697	0.791	1.000	1.000	0.680	1.000	0.761	0.742	0.785	1.000	0.799	0.738	1.000	0.817	0.728	1.000	1.000	0.885	0.713	1.000	0.710
	TG	0.232	0.004	0.032	0.120	0.208	0.142	0.004	0.086	0.006	0.047	0.049	0.291	0.015	0.000	0.102	0.024	0.253	0.000	0.199	0.179	0.045	0.000
2008	TE	1.000	0.701	0.797	1.000	1.000	0.681	1.000	0.764	0.744	0.790	1.000	0.861	0.739	1.000	0.823	0.734	1.000	1.000	0.907	0.719	1.000	0.716
	TG	0.231	0.001	0.031	0.166	0.136	0.169	0.004	0.085	0.006	0.023	0.052	0.287	0.010	0.000	0.104	0.023	0.240	0.000	0.198	0.191	0.050	0.000
2009	TE	1.000	0.700	0.802	1.000	1.000	0.685	0.960	0.773	0.745	0.773	1.000	0.732	0.737	1.000	0.852	0.732	1.000	1.000	0.900	0.815	1.000	0.730
	TG	0.050	0.000	0.034	0.263	0.000	0.160	0.008	0.094	0.006	0.051	0.030	0.284	0.010	0.000	0.133	0.024	0.148	0.000	0.199	0.189	0.079	0.000
2010	TE	1.000	0.699	0.808	1.000	1.000	0.680	0.928	0.769	0.747	0.748	1.000	0.730	0.732	1.000	0.855	0.728	1.000	1.000	0.919	0.721	1.000	0.726
	TG	0.219	0.001	0.032	0.263	0.000	0.147	0.001	0.090	0.008	0.059	0.004	0.280	0.007	0.020	0.133	0.019	0.229	0.000	0.199	0.199	0.045	0.000
2011	TE	1.000	1.000	0.813	1.000	1.000	0.682	0.917	0.767	1.000	0.744	1.000	0.789	0.734	1.000	0.854	0.731	1.000	1.000	0.941	0.754	1.000	0.725
	TG	0.000	0.280	0.021	0.261	0.097	0.145	0.001	0.088	0.000	0.000	0.003	0.000	0.004	0.010	0.133	0.021	0.243	0.000	0.199	0.187	0.000	0.000
	Mean TE	0.994	0.707	0.790	1.000	0.797	0.750	0.989	0.769	0.788	0.871	1.000	0.905	0.742	0.997	0.795	0.734	1.000	0.865	0.878	0.725	1.000	0.718
	Mean TG	0.141	0.019	0.034	0.249	0.050	0.123	0.080	0.094	0.005	0.019	0.137	0.284	0.027	0.002	0.086	0.030	0.110	0.009	0.209	0.175	0.050	0.000

		IND	IRN	IRQ	ISR	JOR	KAZ	KEN	KGZ	KHM	KUW	LKA	MAR	MDA	MEX	FYR	MOZ	MYS	NIG	OMA	PAK	PER	PHIL
1995	TE	1.000	0.819	0.686	0.870	0.793	0.700	0.711	1.000	1.000	1.000	1.000	0.693	0.766	1.000	1.000	1.000	0.757	0.681	1.000	0.710	0.747	0.699
	TG	0.062	0.000	0.029	0.000	0.034	0.086	0.000	0.034	0.304	0.000	0.000	0.007	0.085	0.181	0.000	0.024	0.006	0.156	0.023	0.027	0.012	0.000
1996	TE	1.000	0.821	0.694	0.880	0.781	0.700	0.711	1.000	1.000	1.000	1.000	0.696	0.774	1.000	1.000	1.000	0.758	0.680	1.000	0.713	0.745	0.700
	TG	0.015	0.000	0.030	0.000	0.048	0.076	0.000	0.045	0.303	0.000	0.000	0.009	0.095	0.153	0.000	0.026	0.006	0.154	0.028	0.031	0.013	0.000
1997	TE	1.000	0.812	0.695	0.877	0.782	0.701	0.710	1.000	1.000	1.000	0.887	0.692	0.829	1.000	1.000	1.000	0.759	0.681	1.000	0.705	0.743	0.701
	TG	0.012	0.000	0.025	0.002	0.055	0.083	0.003	0.045	0.304	0.014	0.168	0.008	0.155	0.156	0.000	0.024	0.007	0.152	0.019	0.023	0.014	0.000
1998	TE	1.000	0.803	0.709	0.920	0.797	0.699	0.702	1.000	1.000	1.000	1.000	0.696	0.867	1.000	1.000	1.000	0.747	0.684	1.000	0.703	0.750	0.700
	TG	0.010	0.000	0.020	0.008	0.102	0.101	0.005	0.035	0.304	0.049	0.000	0.012	0.193	0.147	0.000	0.018	0.012	0.154	0.018	0.031	0.013	0.000
1999	TE	1.000	0.802	0.867	1.000	0.788	0.701	0.702	1.000	1.000	1.000	1.000	0.695	0.902	1.000	1.000	1.000	0.754	0.680	1.000	0.707	0.750	0.699
	TG	0.011	0.000	0.025	0.176	0.170	0.091	0.005	0.035	0.303	0.086	0.171	0.013	0.224	0.176	0.000	0.025	0.007	0.154	0.024	0.033	0.012	0.000
2000	TE	1.000	0.798	0.861	1.000	0.783	0.704	0.701	1.000	1.000	1.000	0.834	0.690	0.921	1.000	1.000	1.000	0.756	0.678	1.000	0.709	0.746	0.700
	TG	0.012	0.000	0.027	0.175	0.170	0.086	0.007	0.036	0.296	0.103	0.162	0.007	0.240	0.000	0.000	0.026	0.004	0.172	0.025	0.032	0.013	0.000
2001	TE	1.000	0.799	0.885	0.994	0.770	0.709	0.706	1.000	1.000	1.000	0.773	0.695	0.907	1.000	1.000	1.000	0.758	0.687	1.000	0.712	0.747	0.699
	TG	0.016	0.000	0.034	0.197	0.171	0.072	0.011	0.040	0.254	0.120	0.096	0.011	0.226	0.179	0.000	0.030	0.015	0.156	0.029	0.028	0.013	0.000
2002	TE	1.000	0.831	0.813	0.963	0.766	0.715	0.710	1.000	1.000	1.000	0.762	0.696	0.890	1.000	1.000	1.000	0.764	0.726	1.000	0.717	0.747	0.699
	TG	0.012	0.000	0.071	0.138	0.151	0.068	0.014	0.047	0.263	0.132	0.085	0.012	0.211	0.189	0.000	0.035	0.066	0.162	0.036	0.031	0.013	0.000
2003	TE	1.000	0.856	0.683	0.892	0.765	0.719	0.768	1.000	1.000	1.000	0.896	0.698	0.922	1.000	1.000	1.000	0.767	0.749	1.000	0.715	0.754	0.700
	TG	0.035	0.000	0.097	0.000	0.084	0.065	0.016	0.047	0.000	0.086	0.219	0.013	0.233	0.192	0.000	0.038	0.091	0.170	0.033	0.031	0.014	0.000
2004	TE	1.000	0.848	0.796	0.878	0.749	0.718	0.735	1.000	1.000	1.000	0.751	0.694	0.926	1.000	1.000	1.000	0.767	0.787	0.978	0.720	0.739	0.700
	TG	0.022	0.000	0.093	0.119	0.069	0.046	0.015	0.043	0.000	0.087	0.075	0.009	0.234	0.196	0.000	0.036	0.131	0.159	0.040	0.022	0.014	0.000
2005	TE	1.000	0.847	0.751	0.883	0.749	0.725	0.713	1.000	1.000	1.000	0.787	0.691	0.934	1.000	1.000	1.000	0.772	1.000	0.956	0.728	0.736	0.701
	TG	0.012	0.000	0.093	0.061	0.066	0.043	0.017	0.030	0.000	0.047	0.112	0.006	0.238	0.199	0.000	0.038	0.284	0.147	0.049	0.018	0.014	0.000
2006	TE	1.000	0.863	0.820	0.855	0.768	0.725	0.710	1.000	1.000	1.000	0.763	0.693	0.945	1.000	1.000	1.000	0.770	1.000	0.842	0.727	0.733	0.701
	TG	0.020	0.000	0.103	0.134	0.037	0.057	0.012	0.038	0.000	0.051	0.075	0.007	0.243	0.198	0.000	0.030	0.000	0.040	0.048	0.011	0.012	0.000
2007	TE	1.000	0.906	0.864	0.864	0.784	0.728	0.711	1.000	1.000	1.000	0.761	0.695	0.989	1.000	1.000	1.000	0.773	1.000	0.870	0.731	0.730	0.702
	TG	0.022	0.000	0.135	0.174	0.037	0.069	0.009	0.035	0.000	0.040	0.071	0.007	0.274	0.199	0.000	0.026	0.000	0.054	0.052	0.008	0.011	0.000
2008	TE	1.000	0.904	0.891	0.929	0.802	0.726	0.709	1.000	1.000	1.000	0.849	0.696	1.000	1.000	1.000	1.000	0.776	1.000	0.901	0.731	0.734	0.702
	TG	0.029	0.000	0.128	0.194	0.105	0.082	0.005	0.042	0.000	0.040	0.147	0.006	0.279	0.198	0.000	0.024	0.000	0.065	0.051	0.007	0.008	0.000
2009	TE	1.000	0.973	0.934	1.000	0.805	0.725	0.708	1.000	1.000	0.933	0.767	0.699	0.985	1.000	1.000	1.000	0.772	1.000	0.906	0.763	0.735	0.702
	TG	0.045	0.000	0.187	0.204	0.163	0.083	0.002	0.042	0.000	0.009	0.061	0.007	0.266	0.210	0.000	0.023	0.000	0.069	0.088	0.008	0.008	0.000
2010	TE	1.000	0.964	0.919	0.889	0.805	0.722	0.708	1.000	1.000	0.935	0.766	0.698	0.995	1.000	1.000	1.000	0.766	1.000	0.904	0.750	0.731	0.702
	TG	0.040	0.000	0.178	0.190	0.067	0.084	0.000	0.042	0.000	0.015	0.049	0.007	0.269	0.203	0.000	0.022	0.000	0.069	0.072	0.003	0.005	0.000
2011	TE	1.000	0.924	0.933	0.891	0.802	0.722	0.706	1.000	1.000	0.934	1.000	0.698	0.983	1.000	1.000	1.000	0.762	1.000	0.901	0.751	0.738	0.700
	TG	0.034	0.000	0.149	0.174	0.074	0.083	0.002	0.028	0.000	0.018	0.000	0.302	0.258	0.193	0.000	0.021	0.000	0.071	0.072	0.005	0.004	0.000
	Mean TE	1.000	0.857	0.812	0.917	0.782	0.714	0.713	1.000	1.000	0.988	0.858	0.695	0.914	1.000	1.000	1.000	0.763	0.825	0.956	0.723	0.741	0.700
	Mean TG	0.024	0.000	0.084	0.114	0.094	0.075	0.007	0.039	0.137	0.053	0.088	0.026	0.219	0.175	0.000	0.027	0.037	0.124	0.041	0.021	0.011	0.000

																						St.Dev	
		QAT	SAU	SUD	SEN	SGP	SKO	SYR	THA	TJK	TKM	TTO	TUN	TZA	URU	UZB	VEN	VIET	YEM	ZAF	ZAM	Mean	
1995	TE	1.000	1.000	1.000	0.803	0.884	0.700	0.723	0.863	0.716	1.000	0.751	0.728	1.000	0.690	0.785	0.698	0.748	0.848	0.972	0.956	0.850	0.128
	TG	0.054	0.147	0.041	0.166	0.000	0.000	0.014	0.193	0.008	0.176	0.051	0.016	0.000	0.000	0.032	0.032	0.064	0.131	0.224	0.028	0.065	0.084
1996	TE	1.000	1.000	1.000	0.788	0.853	0.702	0.726	0.868	0.716	1.000	0.746	0.730	1.000	0.691	0.778	0.695	0.771	0.863	0.962	0.776	0.848	0.128
	TG	0.049	0.132	0.025	0.144	0.000	0.000	0.016	0.200	0.008	0.136	0.044	0.000	0.236	0.001	0.031	0.027	0.086	0.149	0.049	0.038	0.066	0.084
1997	TE	1.000	1.000	1.000	0.787	0.857	0.698	0.720	0.862	0.715	1.000	0.748	1.000	1.000	0.691	0.778	0.686	0.761	0.846	0.895	0.951	0.847	0.127
	TG	0.044	0.131	0.030	0.115	0.000	0.002	0.013	0.176	0.018	0.083	0.050	0.000	0.222	0.002	0.029	0.014	0.075	0.135	0.185	0.105	0.070	0.084
1998	TE	1.000	1.000	1.000	0.782	0.856	0.697	0.717	0.859	0.717	1.000	0.744	1.000	1.000	0.697	0.770	0.687	0.764	0.828	0.939	0.815	0.851	0.129
	TG	0.034	0.126	0.046	0.032	0.000	0.003	0.013	0.192	0.020	0.000	0.048	0.000	0.196	0.013	0.023	0.015	0.081	0.119	0.252	0.061	0.071	0.090
1999	TE	1.000	1.000	1.000	0.776	0.892	0.693	0.718	1.000	0.715	1.000	0.761	1.000	1.000	0.723	0.760	0.683	0.757	0.836	1.000	0.748	0.858	0.131
	TG	0.043	0.119	0.074	0.049	0.000	0.002	0.014	0.304	0.018	0.000	0.066	0.000	0.229	0.048	0.023	0.009	0.074	0.130	0.000	0.000	0.080	0.094
2000	TE	1.000	1.000	1.000	0.771	0.907	0.689	0.718	1.000	0.717	1.000	0.753	1.000	1.000	0.722	0.760	0.680	0.756	0.836	1.000	1.000	0.858	0.132
	TG	0.051	0.114	0.074	0.057	0.000	0.000	0.015	0.302	0.019	0.000	0.061	0.000	0.230	0.048	0.024	0.005	0.073	0.132	0.000	0.000	0.079	0.096
2001	TE	1.000	1.000	1.000	0.758	0.877	0.689	0.720	1.000	0.716	1.000	0.741	1.000	1.000	0.745	0.764	0.681	0.756	0.876	1.000	1.000	0.855	0.130
	TG	0.068	0.099	0.063	0.052	0.000	0.001	0.018	0.000	0.017	0.000	0.041	0.000	0.000	0.075	0.031	0.006	0.074	0.172	0.000	0.000	0.065	0.080
2002	TE	1.000	0.987	1.000	0.746	0.892	0.689	0.722	1.000	0.712	1.000	0.736	1.000	1.000	0.754	0.756	0.682	0.764	0.908	1.000	1.000	0.855	0.129
	TG	0.080	0.087	0.070	0.082	0.000	0.001	0.019	0.000	0.014	0.000	0.036	0.000	0.000	0.086	0.032	0.006	0.084	0.201	0.000	0.000	0.070	0.082
2003	TE	1.000	0.992	1.000	0.744	0.975	0.688	0.725	1.000	0.709	1.000	0.741	1.000	1.000	0.764	0.745	0.683	0.760	0.905	1.000	1.000	0.858	0.130
	TG	0.091	0.083	0.124	0.061	0.000	0.000	0.021	0.000	0.009	0.000	0.040	0.000	0.000	0.094	0.029	0.007	0.079	0.198	0.000	0.000	0.066	0.080
2004	TE	1.000	0.973	1.000	0.739	0.996	0.689	0.725	1.000	0.709	1.000	0.739	1.000	1.000	0.785	0.756	0.682	0.748	0.909	1.000	1.000	0.856	0.129
	TG	0.088	0.077	0.125	0.061	0.000	0.001	0.020	0.000	0.009	0.000	0.037	0.000	0.238	0.118	0.031	0.006	0.067	0.201	0.000	0.000	0.072	0.081
2005	TE	1.000	0.966	1.000	0.735	0.996	0.692	0.725	1.000	0.715	1.000	0.743	0.759	1.000	0.810	0.768	0.684	0.736	0.923	1.000	1.000	0.861	0.128
	TG	0.087	0.073	0.115	0.062	0.000	0.001	0.020	0.000	0.011	0.000	0.039	0.029	0.235	0.138	0.036	0.007	0.053	0.210	0.000	0.000	0.072	0.084
2006	TE	1.000	0.938	1.000	0.738	0.968	0.698	0.726	1.000	0.725	1.000	0.743	0.752	0.895	0.860	0.773	0.684	0.723	0.926	1.000	1.000	0.858	0.124
	TG	0.065	0.076	0.089	0.060	0.000	0.004	0.018	0.000	0.018	0.000	0.038	0.013	0.168	0.182	0.030	0.005	0.036	0.206	0.000	0.000	0.063	0.077
2007	TE	1.000	0.926	1.000	0.735	1.000	0.707	0.727	1.000	0.740	1.000	0.750	0.774	0.902	0.930	0.784	0.684	0.716	0.949	1.000	1.000	0.864	0.125
	TG	0.058	0.072	0.000	0.060	0.000	0.007	0.017	0.291	0.027	0.000	0.040	0.040	0.166	0.236	0.032	0.005	0.025	0.221	0.000	0.000	0.071	0.087
2008	TE	1.000	0.928	1.000	0.736	1.000	0.717	0.727	1.000	0.759	1.000	0.750	0.859	0.882	1.000	0.827	0.685	0.714	0.954	1.000	1.000	0.873	0.123
	TG	0.057	0.073	0.000	0.061	0.000	0.013	0.017	0.000	0.039	0.000	0.038	0.069	0.149	0.125	0.077	0.004	0.022	0.220	0.000	0.000	0.068	0.080
2009	TE	1.000	0.924	1.000	0.726	0.953	0.725	0.726	1.000	0.767	1.000	0.751	0.974	0.882	1.000	0.821	0.686	0.713	0.949	1.000	1.000	0.874	0.122
	TG	0.060	0.060	0.030	0.067	0.000	0.015	0.017	0.000	0.043	0.000	0.036	0.050	0.147	0.000	0.079	0.004	0.022	0.216	0.000	0.000	0.064	0.079
2010	TE	1.000	0.918	1.000	0.719	1.000	0.725	0.728	1.000	0.770	1.000	0.746	0.815	0.911	1.000	0.760	0.685	0.713	0.925	1.000	1.000	0.867	0.124
	TG	0.061	0.052	0.000	0.072	0.000	0.017	0.019	0.000	0.043	0.000	0.032	0.000	0.159	0.000	0.018	0.004	0.022	0.194	0.000	0.000	0.062	0.082
2011	TE	1.000	0.921	1.000	0.726	0.880	0.723	0.725	1.000	0.772	1.000	0.745	0.951	0.912	1.000	0.754	0.685	0.708	0.905	1.000	1.000	0.880	0.121
	TG	0.063	0.062	0.008	0.047	0.000	0.019	0.018	0.000	0.042	0.000	0.034	0.000	0.154	0.000	0.015	0.003	0.022	0.178	0.000	0.000		
Mean TE		1.000	0.969	1.000	0.753	0.929	0.701	0.723	0.968	0.729	1.000	0.746	0.903	0.964	0.815	0.773	0.685	0.742	0.893	0.986	0.956		
Mean TG		0.062	0.093	0.054	0.073	0.000	0.005	0.017	0.098	0.021	0.023	0.043	0.013	0.149	0.069	0.034	0.009	0.056	0.177	0.042	0.014		

Appendix B

Figure 1: Meta-frontier, individual frontiers, for the single output-single output case.



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Figure 2: Kernel densities of the productive efficiency for Annex-I, non-Annex-I and total countries group in 1995, 2000, 2005 & 2011

Fig. 2a

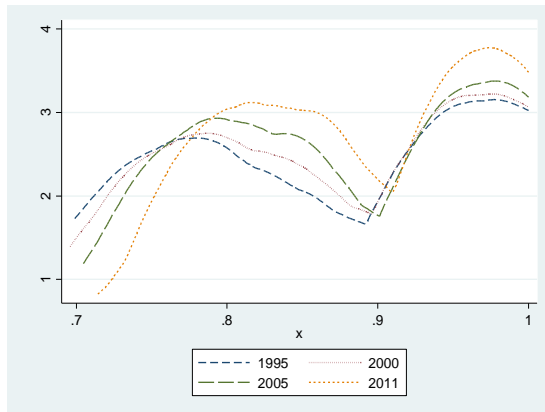


Fig. 2b

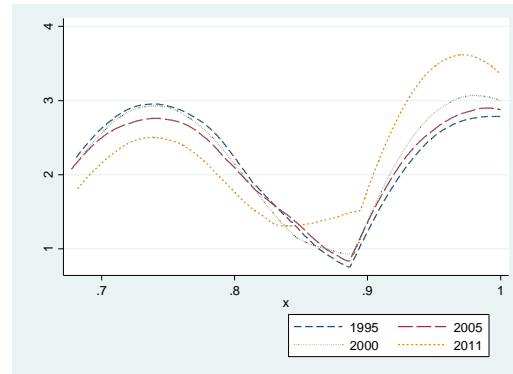


Fig. 2c

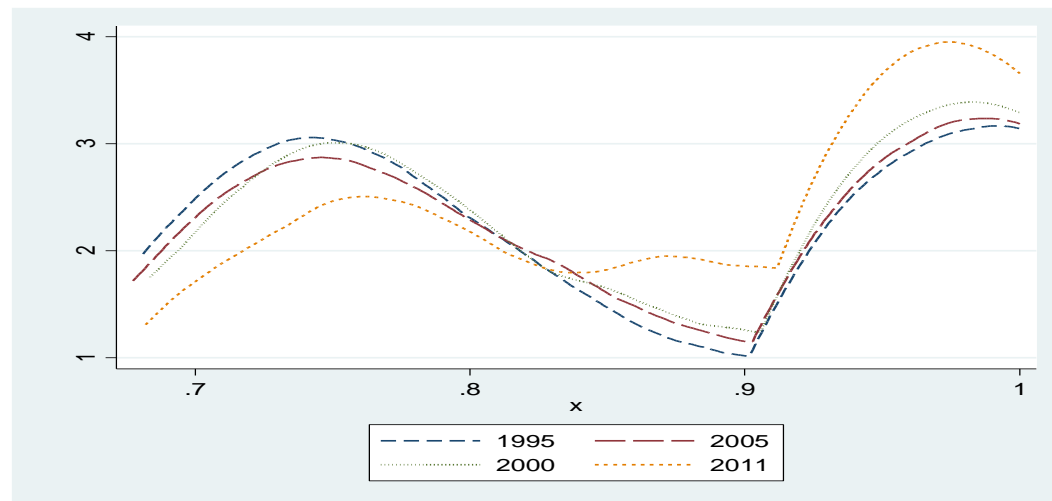


Figure 3: Box-plot of Metatechnology ratios for Annex-I, non-Annex-I and total countries group

Fig. 3a

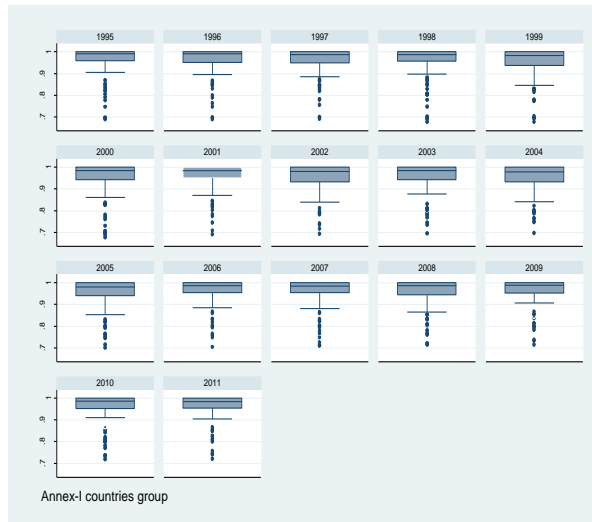


Fig. 3b

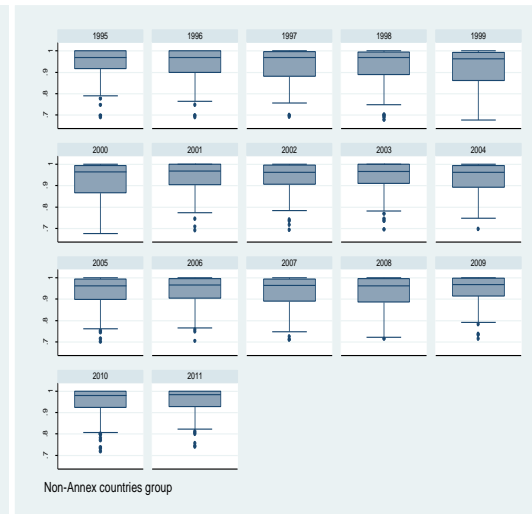


Fig. 3c

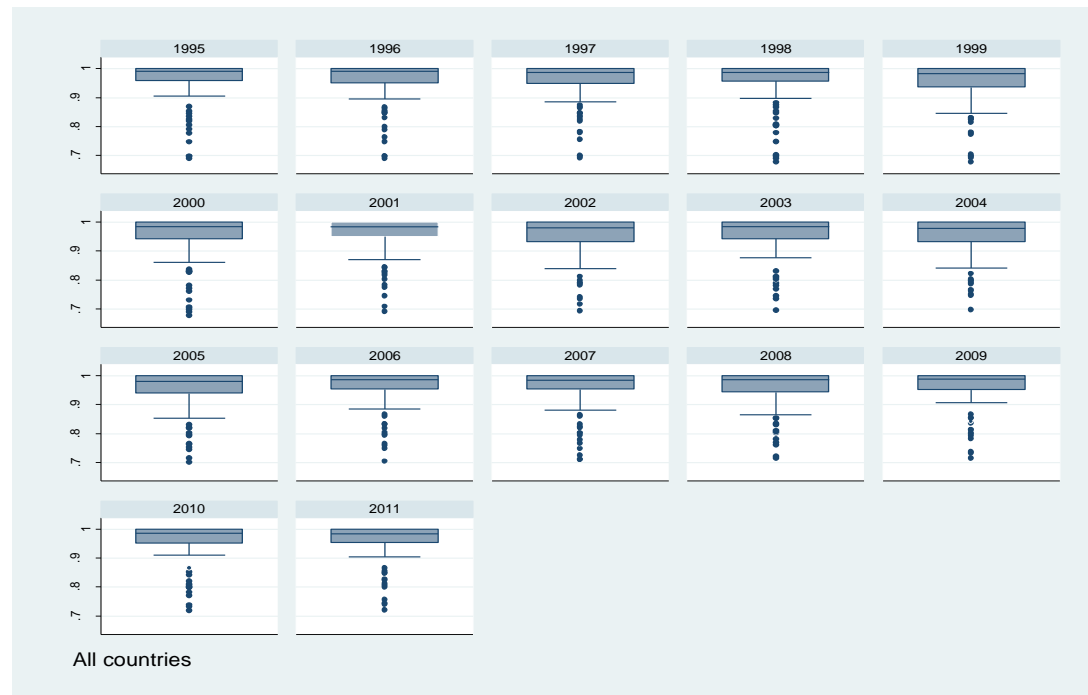


Figure 4: Stochastic kernel of the distribution of Technology gaps.

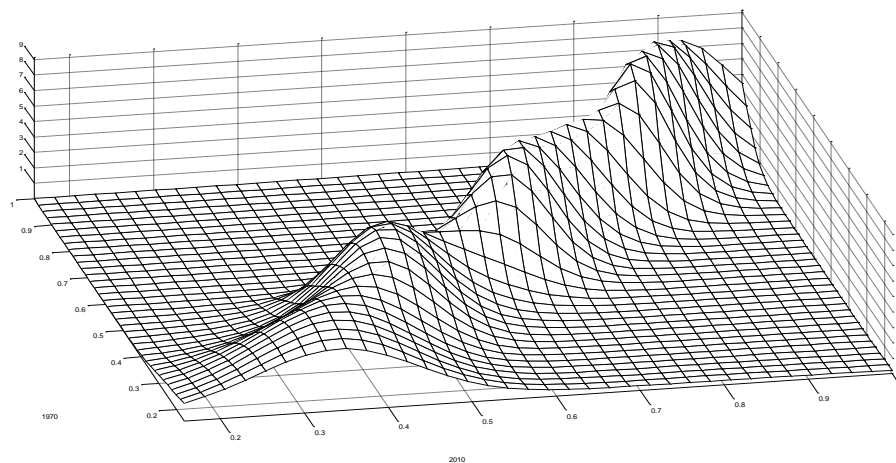


Figure 5: Contour plot of the distribution of Technology gaps.

